

Evaluation of Novel Device “Obturagun” as a Root Canal Obturating Technique for Primary Teeth: An *In Vitro* Study

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ABSTRACT

Aims and objectives: Pulpectomy is one of the most commonly rendered treatment modalities in primary teeth wherein the pulp is irreversibly inflamed. To evaluate the sufficiency of calculated obturating material and quality of obturation in primary teeth using an obturagun device.

Materials and methods: Average root canal volume of 65 and 75 was calculated from cone beam computed tomography (CBCT) scans of children in the age-group of 5–9 years. Based on the average root canal volume and density of obturating material (Vitapex), quantity of obturating material required to obturate a single primary mandibular second molar was calculated. Computer-aided design (CAD)/computer-aided manufacturing (CAM) software was used to design obturagun, which was three-dimensional (3D) printed for study purposes. An *in vitro* pilot study (pulpectomy) was conducted on 20 extracted primary mandibular second molar to evaluate the efficacy of the obturagun.

Results: Average root canal volume of 75 was larger than 65. Approximately 68% of the root canals showed optimal obturation. Distal root canals were more void free as compared to mesial. In 70% of the cases, the calculated obturation material was sufficient to obturate a single primary mandibular second molar.

Conclusion and clinical significance: Average root canal volume can be used to determine the quantity of obturating material. Obturagun can be used as an alternate obturating technique for primary teeth.

Keywords: Density, Obturating material, Pulpectomy, Root canal volume.

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INTRODUCTION

The success of endodontic treatment of primary teeth primarily depends on obturating technique and obturation material.^{1,2} Till date, various nonsyringe and syringe obturating techniques have been used to obturate root canals of primary teeth, such as—Lentulo spiral, bi-directional spiral, incremental technique (endodontic pluggers), past inject, disposable syringe, NaviTip, pressure syringe, Jiffy Tubes, etc. The majority of the syringe and nonsyringe techniques are associated with over-obturation, under-obturation, wastage of obturating material, increased obturation time, difficulty in placing rubber stop correctly, difficulty in removing needles, increased risk of voids, and syringe phobia.^{3–8}

Non-setting calcium hydroxide premixed syringe (Vitapex/Metapex) has been the popular root canal obturating technique for primary teeth among the oral healthcare providers because of its ease of use and ready to use obturating material in the syringe. But this technique is also associated with increased wastage and contamination of obturating material. Additionally, the syringe form of the device develops syringe phobia among children, which ultimately affects obturation time and quality of obturation.^{9,10}

Surprisingly, till date, no obturating technique has been designed and developed based on the concept of the average root canal volume of a single tooth and camouflage that can overcome the disadvantages of currently practiced obturating techniques. In the current study, a novel device, “obturagun” has been designed for root canal obturation of primary teeth. Obturagun consists of two parts; a volume-based ampule and a gun toy. The volume-based ampule is based on the concept of root canal volume of a single primary posterior tooth that can reduce over-obturation, wastage, and

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contamination of obturating material. Similarly, the gun toy is based on the concept of camouflage that reduces syringe phobia, thus reducing obturation time and improving the quality of obturation. Therefore, an *in vitro* pilot study was conducted to evaluate the sufficiency of obturating material (Vitapex/Metapex) calculated from the average root canal volume of the primary mandibular second molar to obturate single primary second molar (extracted), and to assess the quality of obturation using an obturagun.

MATERIALS AND METHODS

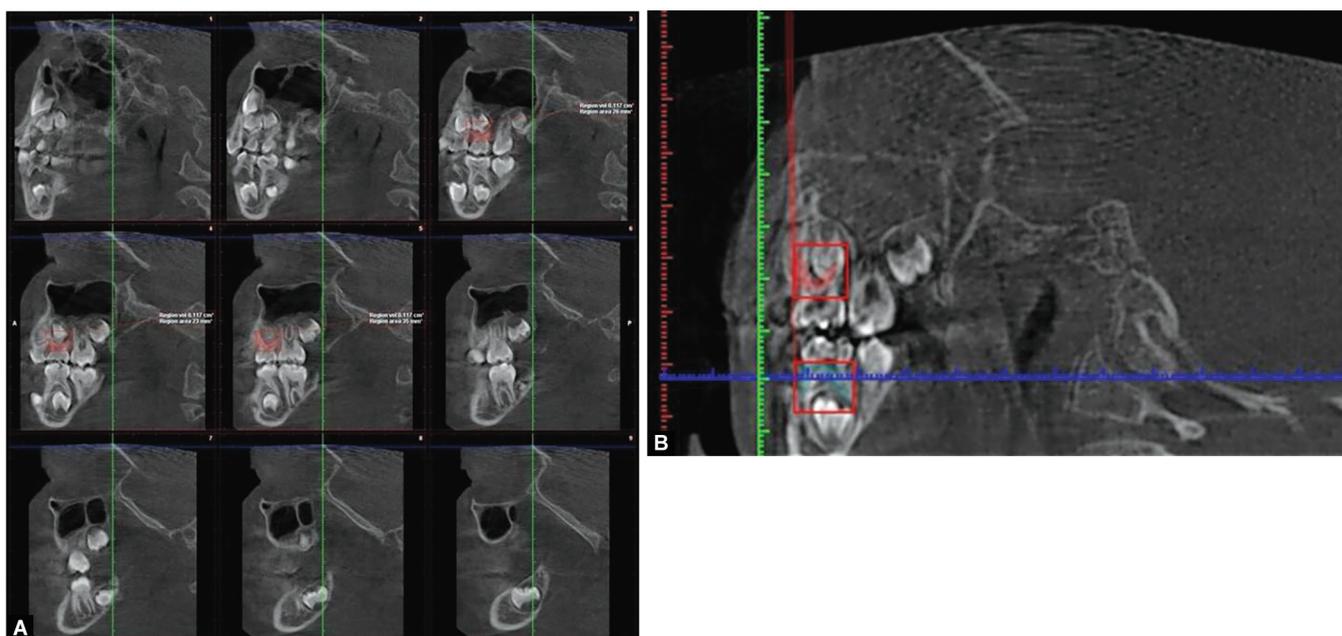
Calculation of Average Root Canal Volume of Primary Second Molar

The *in vitro* pilot study was conducted in the Department of Pediatric and Preventive Dentistry from December 2020 to July 2021. The average root canal volume of primary second molars (65 and 75) was calculated using 31 already exposed CBCT (Planmeca, ProMax, 3D, Finland) scans of children or children who were in the need of CBCT. Scans of children in the age-group of 5–9 years without any carious lesion, periapical pathology, and internal root resorption were included. The sagittal section from CBCT scans of primary second molars (65 and 75) was divided into nine sections of 0.4 mm thickness. A manual segmentation tool was used to delineate the root canal in all sections to calculate root canal volume in cm^3 (Fig. 1).

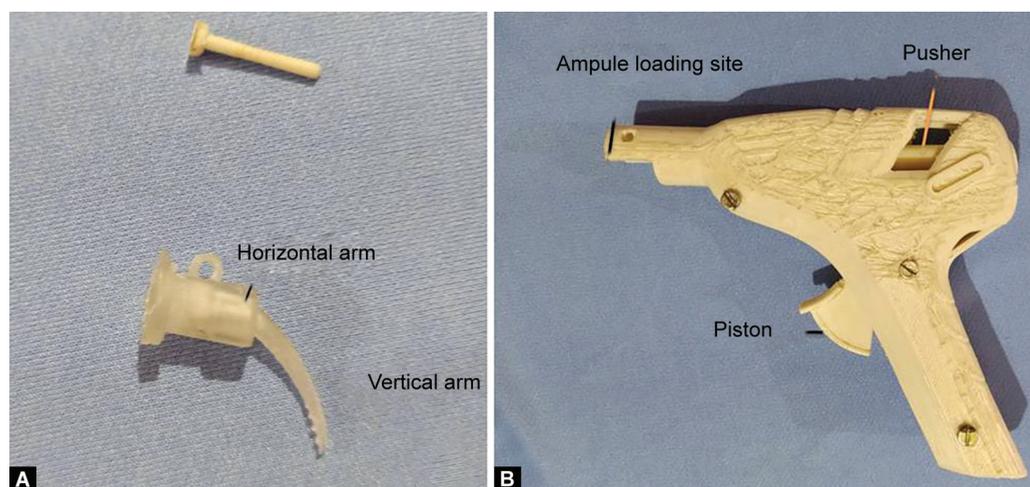
Developing of Obturagun

Obturagun consists of two parts—a volume-based ampule and a gun toy. CAD/CAM, (PTC Inc, Boston, Massachusetts) was used for designing the obturagun. Volume of the primary mandibular second molar was considered in developing the volume-based ampule because it is the tooth with the largest pulp cavity volume. The volume-based ampules contain a specific amount of obturating material that is sufficient to obturate a single primary second molar. It consists of a vertical arm and a horizontal arm (cylindrical tube). The cylindrical tube contains a specific quantity of obturating material which is calculated from the average root canal volume (Fig. 2A). For study purposes, resin material was used for 3D printing of the volume-based ampule (Flashforge Hunter 3D printer).

A gun toy is a camouflage device used to reduce anxiety among children. It consists of an ampule loading site, pusher, and piston.



Figs 1A and B: Sagittal section of CBCT: (A) Scans of primary second molars divided into nine sections of 0.4 mm thickness; (B) Overall root canal volume (65 and 75)



Figs 2A and B: Obturagun: (A) Photograph of a volume-based ampule; (B) Photograph of a gun toy

At the ampule loading site, a volume-based ampule is attached and the pusher is surrounded by a strong spring to generate pressure. At the tip of the pusher, a rubber stopper is attached that is used to dispense the obturating material in the vertical arm of volume-based ampule when piston is pressed (Fig. 2B). Polylactic acid filament of diameter 1.75 was used for 3D printing by fused deposition modeling method.

In Vitro Pilot Study

To evaluate the efficiency of the novel device and the sufficiency of calculated obturating material, a pilot study was conducted on 20 extracted primary mandibular second molars. Average root canal volume was used to calculate the quantity of obturating material required to obturate a single primary mandibular second molar by using the formula “mass = density × volume.”

- Mass: calculated gm/quantity of obturating material.
- Density: density of Vitapex paste (2.07 gm/cm³).
- Volume: average root canal volume of the primary mandibular second molar (0.132 cm³).
- Mass = 2.07 × 0.132
- Mass = 0.2732 (0.27) gm

Procedure

Using a high-speed air rotor handpiece, an access cavity was prepared on an extracted primary mandibular second molar (Fig. 3A). Around 10 number of K-files were used to measure length using an intraoral periapical radiograph. The working length was adjusted 1 mm short of the radiographic apex (Fig. 3B). Canals were enlarged up to size 40 using standard K-files (Mani Co., Tokyo, Japan) and irrigated using normal saline. Canals were dried using absorbent paper points (DiaDent Group International, Canada). The volume-based ampule was filled with the desired quantity of obturating material (0.27 gm) (Vitapex paste). Thereafter, a volume-based ampule was locked at the ampule loading site of the gun toy, followed by obturation of root canals were done. An intraoral radiograph of the obturated tooth was taken (Fig. 3C). Only two canals (mesiobuccal and distal) were considered for radiographic evaluation as in the majority of cases mesiolingual canal is superimposed over the mesiobuccal canal (MBC). Coll and Sadrian¹¹ criteria were used to assess the quality of obturation.

Quality of obturation	Score	Radiographic criteria
Underfilling	1	Canal filled >2 mm short of the apex
Optimal filling	2	Canal filling ending at the radiographic apex or up to 2 mm short of the apex
Overfilling	3	Any canal showing filling outside the root apex

For assessing Voids

The presence of voids was evaluated based on the criteria given by Khubchandani et al.¹²

Score	Criteria
0	Complete absence of voids
1	Presence of one void
2	Presence of two voids
3	Presence of three voids
4	Presence of four voids
5	Presence of five voids

The operator was not blinded to the study. A magnifying glass was used to assess the quality of obturation and the presence of voids by a blinded investigator (oral radiologist).

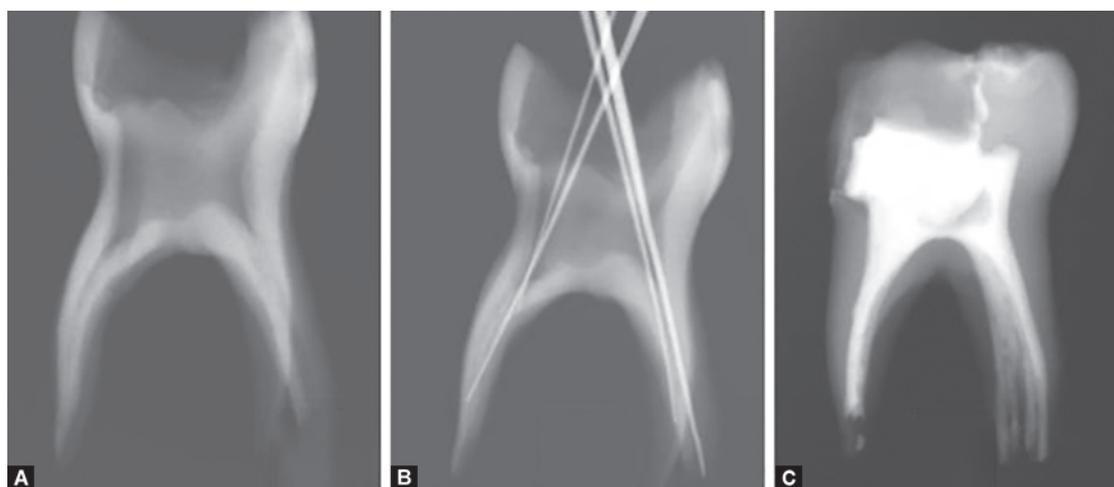
RESULTS

The average root canal volume of the mandibular primary left second molar [0.132 cm³, standard deviation (SD) ± 0.019] was larger than the maxillary primary left second molar (0.112 cm³, SD ± 0.024) (Table 1). The difference was not statistically significant. Thus, the tooth with a larger root canal volume was preferred in designing and developing of the volume-based ampule.

Optimal obturation was observed in 67.5% of root canals, whereas under-obturation and over-obturation were observed in

Table 1: Mean root canal volume of 65 and 75

Tooth	Mean Root canal Volume in cm ³	SD	p-value
65	0.112	±0.024	0.002
75	0.132	±0.019	



Figs 3A to C: Photographs of in-vitro endodontics treatment of primary mandibular molar: (A) Preoperative radiograph; (B) Diagnostic radiograph; (C) Obturation using Vitapex

Table 2: Obturation quality in the mandibular primary second molar

	Primary mandibular second molar			p-value
	MBC N (%)	D N (%)	Total N (%)	
Underfill	5 (25)	3 (15)	8 (20%)	0.35
Optimal obturation	13 (65)	14 (70)	27 (67.5%)	
Over-obturation	2 (10)	3 (15)	5 (12.5%)	
Total	20	20	40	

D, distal canal; MBC, mesiobuccal canal

Table 3: Presence or absence of voids in both the canals

Scores	Mesial canal	D
0	11 (55%)	13 (65%)
1	5 (25%)	3 (15%)
2	4 (20%)	4 (20%)
p-value	0.37	

Table 4: Type of root canal obturation (optimal, under, and over-obturation) in mesial and distal root canals in the individual primary mandibular second molar

Sr. No	Type of obturation	Total number of teeth n (%)
1	Optimal obturation in both canals	9 (45%)
2	Optimal obturation + over-obturation	4 (20%)
3	Over-obturation + under-obturation	1 (5%)
4	Optimal obturation + under-obturation	4 (20%)
5	Under-obturation + under-obturation	2 (10%)

20 and 12.5% of root canals, respectively. The difference was not statistically significant. Optimal obturation was observed more in the distal canal (D) as compared to the mesial buccal canal, whereas underfill was observed more in the MBC as compared to the D. Over-obtured root canals were more distal as compared to mesiobuccal (Table 2). Nearly 55% of mesial root canals were free of voids, as compared to 65% of distal root canals (Table 3). The difference was not statistically significant. In approximately 70% of the cases calculated, obturating material was sufficient to obturate, whereas in only 10% of the cases, obturating material was insufficient to obturate the root canals of the primary mandibular second molar (Table 4).

Data analysis was done using the Statistical Package for the Social Sciences (SPSS 11.0). To compare the mean root canal volume of the primary mandibular and maxillary second molar, an independent *t*-test was used. The quality of obturation was compared using Mann–Whitney *U* test. Chi-squared test was used to compare the presence or absence of voids in mesial and distal root canals. The level of significance of “*p*” value at a 95% confidence interval was calibrated as—nonsignificant—*p* > 0.05; significant—0.01, *p* < 0.05; and highly significant—*p* < 0.001.

DISCUSSION

Till date, literature lacks knowledge of the average root canal volume of primary teeth; therefore, data obtained from the current study could not be compared. In the current study, the average root canal volume of the primary second molar (0.132 cm³) was used to calculate the mass or quantity of obturating material using

the formula “mass = density × volume.” The same volume was used to develop the volume-based ampule that can be loaded with specific gram (0.27 gm) of obturating material sufficient to obturate a single primary second molar, thus reducing the chances of over-obturation. In the present pilot study, it has been observed that in 70% of the cases, the calculated obturation material was sufficient to obturate a single primary second molar, with the additive advantages of preventing wastage and contamination of obturating material and also giving flexibility to the clinician to choose the choice of obturating material.

Optimal obturation of root canals with restorable paste is the primary requisite for successful endodontic treatment of primary teeth. Obturation quality in primary teeth is directly influenced by the technique of obturation. Till date, numerous obturating techniques have been used, but none of these techniques is recommended ideal for obturation of primary teeth.^{9,10} Vitapex/Metapex is a widely accepted commercially available premixed syringe obturating technique filled with obturating material. The majority of the literature stated that Vitapex is associated with over-obturation of root canals. Studies conducted by Walia et al.¹³ and Shah¹⁴ documented over-obturation of root canals of primary teeth when obturated with Vitapex or Metapex syringe. Another study conducted by Ozer et al.¹⁵ documented that Metapex syringe alone showed a majorly optimally filled canal. But over-obturation of root canals increased when a Metapex syringe was used with an endoactivator. Another study conducted by Mortazavi and Mesbahi⁹ reported approximately 39% of overfilled root canals when obturated with Vitapex. *In vitro* studies conducted by Gandhi et al.⁴ and Hiremath and Srivastava¹⁶ also reported overfilled root canals of primary teeth with a disposable syringe and endodontic pressure syringe. The probable reason for over-obturation of root canals with premixed syringe can be attributed to the excessive application of pressure during obturation in anticipation that the canals are not filled completely. In addition, the syringe form of the device makes the children uncomfortable on the dental chair, which influences optimal obturation, obturation time, and quality of obturation.^{5,17} In the current study, the possibility of over-obturation of root canals, wastage, and contamination of obturating material was negligible because the volume-based ampules contain a specific quantity of obturating material which is sufficient to obturate a single tooth.

Anxiety/phobia plays an important role in influencing obturation time and quality of obturation. Most of the currently used primary teeth obturating techniques are syringe based. Although it is not documented but premixed syringes being a syringe form of obturating technique, develop syringe phobia among children. In the current study, a gun toy was developed that not only acts as a camouflage device, eliminating syringe phobia, but also generates constant pressure due to a spring mechanism

to dispense obturating material from the volume-based ampule into root canals. It can be assumed that the obturagun will be acceptable by children and will contribute toward improving the quality of obturation.

Voids are inevitable during obturation. In the current pilot study, 55% of the mesial and 65% of the distal root canal showed voids. The majority of the voids were observed in the middle third of the canals. This observation from the current pilot study is in accordance with the reported literature. A study conducted by Ozer et al.¹⁵ using a Vitapex syringe showed voids mostly in the middle and coronal third. Other studies were conducted by Kumar et al.,¹⁸ Ellana Jermiah et al.,³ and Pandranki et al.¹⁹ using an endodontic plugger, NaviTip; Lentulo spiral also showed voids similar to a premixed syringe (Vitapex). Although voids are similar to other obturating devices, a clinical trial should be conducted to evaluate the quality of obturation and the presence or absence of voids.

Thus, overall the newly developed obturagun device can reduce wastage and contamination of obturation material, syringe phobia, obturating time, and ultimately, improve the quality of obturation.

CONCLUSION AND CLINICAL SIGNIFICANCE

- The calculated gram of obturating material using average root canal volume was sufficient to obturate a single primary mandibular second molar.
- Obturagun can be recommended as a choice of technique to obturate root canals of primary teeth.

Limitation

A clinical trial should be conducted to evaluate the quality of obturation and voids using an obturagun.

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